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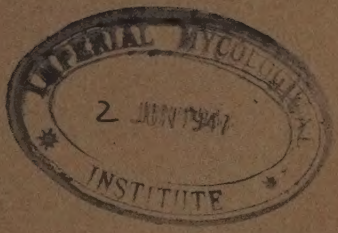

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MATHÉMATIQUES

UN CRITÈRE SIMPLIFIÉ D'EXISTENCE DE FACTEURS LINÉAIRES DANS UNE FORME SYMBOLIQUE

Par G. PFEIFFER, de l'Académie de l'Ukraine

Toute forme symbolique de degré n de $n+k$ variables

$$\sum_{\alpha_1, \ldots, \alpha_n}^{n+k} A_{\alpha_1 \ldots \alpha_n} dx_{\alpha_1} \ldots dx_{\alpha_n} \tag{1}$$

peut être représentée sous la forme

$$\left.\begin{aligned} \Omega_n \equiv M dx_1 \ldots dx_n + \sum_{\sigma_1, \tau_1}^{k,n} M_{\tau_1}^{\sigma_1} dx_1 \ldots dx_{\tau_1 - 1}\, dz_{\sigma_1} dx_{\tau_1 + 1} \ldots dx_n + \\ + \sum_{\sigma_1, \sigma_2, \tau_1, \tau_2}^{k,n} M_{\tau_1 \tau_2}^{\sigma_1 \sigma_2} dx_1 \ldots dx_{\tau_1 - 1}\, dz_{\sigma_1} dx_{\tau_1 + 1} \ldots dx_{\tau_2 - 1}\, dz_{\sigma_2} dx_{\tau_2 + 1} \ldots \\ \ldots dx_n + \ldots \\ M \not\equiv 0. \end{aligned}\right\} \tag{2}$$

Il suffit pour cela de choisir pour M un des coefficients $A_{\alpha_1 \ldots \alpha_n}$ de (1) différent de zéro et de changer les notations, en désignant les variables $x_{\alpha_1}, \ldots, x_{\alpha_n}$ respectivement par $x_1, \ldots, x_n$ et les autres variables par $z_1, \ldots, z_k$.

C'est sur cette forme de (1), à laquelle correspond l'expression linéaire de jacobiens

$$M + \sum_{\sigma_1, \tau_1}^{k,n} M_{\tau_1}^{\sigma_1} \frac{\partial z_{\sigma_1}}{\partial x_{\tau_1}} + \sum_{\sigma_1, \sigma_2, \tau_1, \tau_2}^{k,n} M_{\tau_1 \tau_2}^{\sigma_1 \sigma_2} \frac{\partial (z_{\sigma_1}, z_{\sigma_2})}{\partial (x_{\tau_1}, x_{\tau_2})} + \ldots \tag{3}$$
$$M \not\equiv 0,$$

que nous nous arrêterons.

Pour reconnaître si la forme symbolique (2) contient un facteur linéaire

$$\omega \equiv a_1 dz_1 + \ldots + a_k dz_k - b_1 dx_1 - \ldots - b_n dx_n, \tag{4}$$

on se sert de l'identité

$$\Omega_n \omega \equiv 0. \tag{5}$$

Ce critère conduit à des relations non-indépendantes.

Nous avons trouvé un critère plus simple qui ne donne que des relations indépendantes. Il consiste en ce théorème:

Théorème. *Supposons que la forme* Ω_n (2) *possède un facteur linéaire* ω (4), *c'est-à-dire que*

$$\Omega_n \omega \equiv 0. \tag{6}$$

Nous admettrons que

$$\omega \equiv \lambda d\xi + \tilde{\omega}, \quad \lambda \neq 0, \tag{7}$$

$d\xi$ étant une des différentielles de ω (qui n'entre plus dans $\tilde{\omega}$).

Désignons par $\Omega_{n-1} d\xi$ la somme de tous les termes de Ω_n contenant la différentielle $d\xi$, et le reste désignons par $\overline{\Omega}_n$:

$$\Omega_n \equiv \Omega_{n-1} d\xi + \overline{\Omega}_n; \tag{8}$$

la différentielle $d\xi$ n'entrera alors ni dans Ω_{n-1} ni dans $\overline{\Omega}_n$.

L'identité (6) peut être remplacée par l'identité

$$\lambda \Omega_n \equiv \Omega_{n-1} \omega \tag{9}$$

qui est de degré n et non plus de degré $n+1$ comme (5).

Le cas où la différentielle $d\xi$ est absente dans le facteur ω

$$\omega \equiv \tilde{\omega} \tag{10}$$

est caractérisé par l'identité

$$\Omega_{n-1} \overline{\Omega}_n \equiv 0, \tag{11}$$

mais seulement pour $n \leqslant k$; pour $n > k$ cette identité n'est plus applicable.

D'après les relations (8) et (7) l'identité (9) est équivalente à l'identité

$$\lambda \overline{\Omega}_n \equiv \Omega_{n-1} \tilde{\omega}, \tag{12}$$

plus simple et que (5) et que (9).

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PHYSICS

DIFFUSE REFLECTION OF LIGHT BY A FOGGY MEDIUM

By V. A. AMBARZUMIAN, Corresponding Member of the Academy

The diffuse reflection of light by a foggy medium, that is by such as scatters and absorbs the light, has been the subject of numerous investigations. In all of them a single method has been used which consists in analysing the radiation field within the foggy medium and making the data thus obtained the basis of the subsequent calculation of intensities of the diffuse-reflected radiation emitted by the medium. However, no complete solution of the problem has so far been secured in this way.

Here I propose a different method for solving the problem of the diffuse reflection of light. The new method proves by far more effective than the old one which led to a linear integral equation. Instead of calculating the quantities characterizing the radiation field inside the medium, the new method is confined to the analysis of conditions existing at the boundary of the medium.

Suppose the medium to consist of plane parallel layers and its every element be endowed with scattering and absorbing power. The ratio of the scattering coefficient to that of absorption we denote by $\frac{\lambda}{1-\lambda}$ and take it to be constant throughout the medium. Let us further suppose that the scattering diagram of an elementary volume is a spherical shape. In other words, that the radiation scattered by a given element of the volume, is scattered uniformly in all directions.

At last we assume for the time being that the medium is bounded on one side by a plane A and on the other side extends into infinity, and that its optical thickness is infinitely great. At the end of this paper we shall examine the case of a medium with finite optical thickness.

Let parallel rays be falling upon the boundary plane A. Denote by ξ the cosine of the angle formed by the direction of the incident rays und inner normal to the layers. The flux of this radiation transversing a unit area, that is at right angles to its direction, is supposed to be equal to πS. As a result of scattering, which, generally speaking, is repeated over and over again, the light will be emitted by the medium in different directions and have its intensity I dependent upon the angle between the existing ray and the normal (we denote the cosine of this angle by η) and also upon ξ.

It will be apparent that function $I(\eta, \xi)$ is proportional to S

$$I(\eta, \xi) = r(\eta, \xi) S.$$

Function $r(\eta, \xi)$, characterizing the reflection of light, is the very function it will be our object to find.

Note that if a medium of infinite optical thickness is supplemented at its boundary A by a layer of small optical thicknes $\Delta\tau$, consisting of a substance possessing the same optical properties, then the new medium thus combined will show diffuse reflection, characterized by the same function $r(\eta, \xi s)$. This

property of resting invariant in response to the addition of a supplementary layer will be used by us in deriving the equation, which the function sought for $r(\eta, \xi)$ should satisfy. In the further computations $\Delta\tau$ is supposed to be so small that its square can be neglected.

As a result of adding the layer $\Delta\tau$ we shall have a new boundary for the A' medium. On the former boundary A a weakened flux of straight rays will now be falling, that is $\pi S\left(1-\frac{\Delta\tau}{\xi}\right)$ instead of πS. Accordingly, out of this flux a radiation of intensity $r(\eta, \xi) S\left(1-\frac{\Delta\tau}{\xi}\right)$ will be reflected from the boundary A. But after this radiation has passed through the layer $\Delta\tau$, it will have its intensity weakened $1-\frac{\Delta\tau}{\eta}$ times. Thus, out of the direct radiation falling upon the boundary A only a radiation having an intensity

$$r(\eta, \xi)\left(1-\frac{\Delta\tau}{\xi}\right)\left(1-\frac{\Delta\tau}{\eta}\right) S$$

will be reflected to the outside.

On the other hand, the introduction of the layer $\Delta\tau$ results in the appearance of an additional radiation in the direction η. It consists of four portions:

1) The layer $\Delta\tau$ scatters a part of the direct rays that cross it and some of them follow the direction η. The resulting increment of intensity is

$$\frac{\lambda}{4}\frac{\Delta\tau}{\eta} S.$$

2) Another portion of the direct rays scattered by the layer $\Delta\tau$ is directed towards the boundary A and partly reflected from it. This makes for an increment of intensity equal to

$$\frac{\lambda}{2}\Delta\tau S \int_0^1 r(\eta, \zeta)\,\frac{d\zeta}{\zeta}.$$

3) The reflected radiation from the surface A is also scattered by the $\Delta\tau$ layer. The respective increment of intensity is

$$\frac{\lambda}{2}\frac{\Delta\tau}{\eta} S \int_0^1 r(\zeta, \xi)\, d\zeta.$$

4) Part of the radiation reflected from the surface A is scattered by the layer $\Delta\tau$ back to this surface and is partly again reflected from it. The result is an increment of intensity equal to

$$\lambda\Delta\tau S \int_0^1 r(\zeta, \xi)\, d\zeta \int_0^1 r(\eta, \zeta')\,\frac{d\zeta'}{\zeta'}.$$

Now let us write the condition expressing the fact that, whatever gains or losses have taken place, the intensity issuing from the surface A' remains equal to $r(\eta, \xi) S$:

$$r(\eta, \xi) = r(\eta, \xi)\left(1-\frac{\Delta\tau}{\xi}-\frac{\Delta\tau}{\eta}\right)+\frac{\lambda}{4}\frac{\Delta\tau}{\eta}+\frac{\lambda}{2}\frac{\Delta\tau}{\eta}\int_0^1 r(\zeta, \xi)\, d\zeta +$$

$$+\frac{\lambda}{2}\Delta\tau\int_0^1 r(\eta, \zeta)\,\frac{d\zeta}{\zeta}+\lambda\Delta\tau\int_0^1 r(\zeta, \xi)\, d\zeta\int_0^1 r(\eta, \zeta')\,\frac{d\zeta'}{\zeta'}$$

or

$$\left(\frac{1}{\eta}+\frac{1}{\xi}\right) r(\eta, \xi)=\frac{\lambda}{4}\left\{\frac{1}{\eta}+2\int_0^1 r(\eta, \zeta)\frac{d\zeta}{\zeta}+\frac{2}{\eta}\int_0^1 r(\zeta, \xi)\,d\zeta+\right.$$

$$\left.+4\int_0^1 r(\eta, \zeta')\frac{d\zeta'}{\zeta'}\int_0^1 r(\zeta, \xi)\,d\zeta\right\}.$$

Let us introduce a function $R(\eta, \xi)$ defined by

$$r(\eta, \xi)=\frac{\lambda}{4\eta}R(\eta, \xi). \tag{1}$$

Then for $R(\eta, \xi)$ we have the functional equation

$$\left(\frac{1}{\eta}+\frac{1}{\xi}\right)R(\eta, \xi)=1+\frac{\lambda}{2}\int_0^1 R(\eta, \zeta)\frac{d\zeta}{\zeta}+\frac{\lambda}{2}\int_0^1 R(\zeta, \xi)\frac{d\zeta}{\zeta}+$$

$$+\frac{\lambda^2}{4}\int_0^1 R(\eta, \zeta')\frac{d\zeta'}{\zeta'}\int_0^1 R(\zeta, \xi)\frac{d\zeta}{\zeta}. \tag{2}$$

It will be obvious that if this equation is satisfied by function $R(\eta, \xi)$, it is also satisfied by function $R(\xi, \eta)$. Since our physical problem must have a single solution, we are tempted to seek the solution of equation (2) in the form of symmetrical function

$$R(\eta, \xi)=R(\xi, \eta). \tag{3}$$

But then the right-hand side of equation (2) turns out to be a product of two similar functions

$$\left(\frac{1}{\eta}+\frac{1}{\xi}\right)R(\eta, \xi)=\left\{1+\frac{\lambda}{2}\int_0^1 R(\eta, \zeta)\frac{d\zeta}{\zeta}\right\}\left\{1+\frac{\lambda}{2}\int_0^1 R(\xi, \zeta)\frac{d\zeta}{\zeta}\right\}. \tag{4}$$

Denote

$$\varphi(\eta)=1+\frac{\lambda}{2}\int_0^1 R(\eta, \zeta)\frac{d\zeta}{\zeta}. \tag{5}$$

Then (4) and (5) will at once give the structure of the functions $R(\eta, \xi)$ and $r(\eta, \xi)$:

$$R(\eta, \xi)=\frac{\varphi(\eta)\varphi(\xi)}{\frac{1}{\eta}+\frac{1}{\xi}}\;;\; r(\eta, \xi)=\frac{\lambda}{4}\xi\frac{\varphi(\eta)\varphi(\xi)}{\eta+\xi}. \tag{6}$$

Substitution of (6) in (5) gives the equation for the function

$$\varphi(\eta)=1+\frac{\lambda}{2}\eta\varphi(\eta)\int_0^1\frac{\varphi(\xi)\,d\xi}{\eta+\xi}. \tag{7}$$

Now we arrive at the following conclusion: function $r(\eta, \xi)$ characterizing the reflecting power has its structure expressed by formula (6). Function $\varphi(\eta)$ is thereby defined by the functional equation (7).

As in the physical problem under consideration λ is always smaller than or equal to unity, equation (7) can easily be solved numerically by the method of successive approximations. Thereby the problem of diffuse reflection from an infinitely thick layer is solved completely.

The question arises, whether the functional equations (2) and (7) which have been derived here from physical consideration may not also be obtained in a purely formal way, from the usual integral equation of the diffusion theory. Indeed, this has been done by the author in another paper which will be published elsewhere. There the reader will also find the results of a numerical solution of equation (7) to the third decimal figure.

All that has been said here has been said with reference to the diffuse reflection of light by a medium of infinite optical thickness. Yet the method can as well be generalized to a medium of a finite optical thickness τ, that is to the case of a layer bounded on either side by planes A and B. Then along with the function $r(\eta, \xi)$, characterizing the diffuse reflection, we have to find the function $s(\eta, \xi)$, characterizing the diffuse transmission and bringing out the intensity of the light emitted from the surface B in the direction η, when direct radiation is falling upon the surface A in the direction ξ.

In that case the solution is obtained by making use of the invariance of the sought functions $r(\eta, \xi)$ and $s(\eta, \xi)$, when a layer $\Delta\tau$ is added at the boundary A and at the same time a layer of equal optical thickness is removed at the boundary B.

It turns out that the sought functions are then expressed by two auxiliary functions $\varphi(\eta)$ and $\psi(\eta)$, each of which depends upon one variable only:

$$\left.\begin{aligned} r(\eta, \xi) &= \frac{\lambda}{4}\,\xi\,\frac{\varphi(\eta)\,\varphi(\xi) - \psi(\eta)\,\psi(\xi)}{\eta + \xi}, \\ s(\eta, \xi) &= \frac{\lambda}{4}\,\xi\,\frac{\psi(\eta)\,\varphi(\xi) - \varphi(\eta)\,\psi(\xi)}{\eta - \xi}. \end{aligned}\right\} \tag{8}$$

The auxiliary functions $\varphi(\eta)$ and $\psi(\eta)$ are determined from a system of two functional equations:

$$\left.\begin{aligned} \varphi(\eta) &= 1 + \frac{\lambda}{2}\,\eta\varphi(\eta)\int_0^1 \frac{\varphi(\xi)\,d\xi}{\eta + \xi} - \frac{\lambda}{2}\,\eta\psi(\eta)\int_0^1 \frac{\psi(\xi)\,d\xi}{\eta + \xi}, \\ \psi(\eta) &= e^{-\frac{\tau}{\eta}} + \frac{\lambda}{2}\,\eta\int_0^1 \frac{\psi(\eta)\,\varphi(\xi) - \varphi(\eta)\,\psi(\xi)}{\eta - \xi}\,d\xi. \end{aligned}\right\} \tag{9}$$

The numerical solution of this system also can be obtained by the method of successive approximations.

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PHYSICS

MAGNETIC SPECTRUM IN INFRA-LOW FREQUENCY

By S. S. LAWRENTIEW

(Communicated by A. F. Joffe, Member of the Academy, 10. XI. 1942)

1. In a ferromagnetic the magnetic state corresponding to a given value of the magnetizing field is, generally speaking, established not instantaneously, but after some length of time. This is owing to 1) skin-effect and to 2) magnetic viscosity.

The latter factor comes into play mainly in the case of magnetically soft materials. Ewing (1) has pointed out that when a suitable sample made of a soft ferromagnetic substance is subjected to cyclic magnetization in periodical fields, there should be observed a definite relation between the magnetic cycle and the period of the field; namely, with a certain frequency the area of the hysteresis loop and, accordingly, the energy dissipated within a cycle, should have a maximum. Arkadiev in developing his theory of magnetic spectra (2), gave formulae for the viscous variation of magnetic induction with the frequency of the magnetic field. He has also shown(3) that in the case of a period approaching a minute, magnetically soft materials should exhibit a band of magnetic spectrum, viz. (Fig. 1) the conservative permeability μ (see below § 2) should show a step upwards, while the consumptive permeability ρ' should show a maximum. In this light it seemed very interesting to start an experimental investigation on the course of magnetization of iron in sinusoidal fields of large period lasting as long as several seconds or minutes*, and to establish the shape of the functions

$$\mu = f(T) \text{ and } \rho' = f(T)$$

in this region; all the more so, as such measurements have scarcely been made at all. For a specimen of plain iron Hermann in fields of frequency ranging from 9110 to 0.03 Hertz found a pronounced relation between conservative magnetic permeability μ and the period; Veletzkaya (5) showed this relation to conform well to the theory of Arkadiev. Yet, the dependence of ρ' upon T has not been explored by Hermann, and the question of experimental discovering of the «viscous» absorption band in a magnetic spectrum remains open.

2. Theoretical computations of the run of magnetization of a ferromagnetic possessing magnetic viscosity in a weak sinusoidal field may be carried out, according to Arkadiev (2, 3), by introducing the complex magnetic permeability of the substance given:

$$\mu' = \mu - i\rho'; \qquad (1)$$

* According to the established terminology(4), slow oscillations with periods ranging from $T=1$ second to $T=\infty$ are described as infra-low frequency oscillations.

then induction B in a harmonic field

$$H = H_0 \cos \omega t \tag{2}$$

is expressed as follows:

$$B = \mu H_0 \cos \omega t + \rho' H_0 \sin \omega t. \tag{3}$$

μ characterizes the conservative part of the induction which changes in phase with the field; ρ' characterizes the consumptive part, lagging behing the field by 90° and responsible for the appearance of the hysteresis heat. In the case of magnetic viscosity Arkadiev's theory leads to a dependence of μ and ρ' on the period T of the magnetization field, which is expressed by the functions

$$\mu = m + \frac{m_1 T^2}{T^2 + T_u^2} \tag{4}$$

and

$$\rho' = \rho_1' + \frac{m_1 T T_u}{T^2 + T_u^2}, \tag{5}$$

where m, m_1, ρ_1' and T_u are viscosity constants of the substance given; namely, m defines the «instantaneous» part of the conservative permeability μ, and m_1—the part which is established after some length of time; ρ_1' is the value of consumptive permeability due to hysteresis; and, finally, T_u is the transient constant of magnetic viscosity; its physical meaning is determined from the expression

$$I = I_0 + I_1 (1 - e^{-\frac{2\pi t}{T_u}}) \tag{6}$$

which describes ([3],[6]) the viscous variation of magnetization with time.

The computation of mean values of μ_m and ρ_m' for a cycle at different periods can be made in quadratures *:

$$S_1 = \int_{-\frac{T}{2}}^{+\frac{T}{2}} B\, d \sin \frac{2\pi t}{T} \tag{7}$$

and

$$S_2 = \int_{-\frac{T}{2}}^{+\frac{T}{2}} B\, d \cos \frac{2\pi t}{T}. \tag{8}$$

We have here:

$$\mu_m = \frac{S_1}{\pi H_0} \tag{9}$$

and

$$\rho_m' = \frac{S_2}{\pi H_0}. \tag{10}$$

The curve $B = f(\cos \omega t)$ is, evidently, the ordinary hysteresis curve in the field(2); the curve $B = f(\sin \omega t)$ will be assigned the name of antihysteresis curve.

---

* Formulae (7)—(10) are easily obtained if one considers the expansion of the periodical function $B = f(t)$ into a harmonic series; then equation (3) obviously gives the main harmonics of this series.

3. The method for directly measuring the quantities μ and ρ' has been developed by the author in the following form: a Busch's [7, 8] rheostat alternator, sending into a magnetizing coil, on a uniform rotation of a crankshaft, an alternating current very near to a purely sinusoidal one, is set in motion by an electromotor through a transmission materialized in the form of a special appliance: a) reductor and b) gear box with changeable transmission numbers securing the rotation of the generator's cylinder at periods of 2, 4, 8, 16, etc. seconds, making up 15 octaves. The specimen to be magnetized acts on a movable system of a mirror magnetometer having a very small proper period of oscillations, so that the deviations of a reflected beam of light are at any time very nearly proportional to the magnetization of the sample.

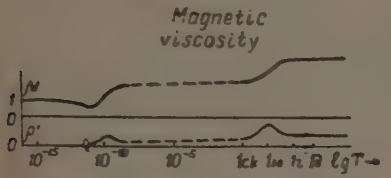

Fig. 1. Scheme of magnetic spectrum according to Arkadiev.

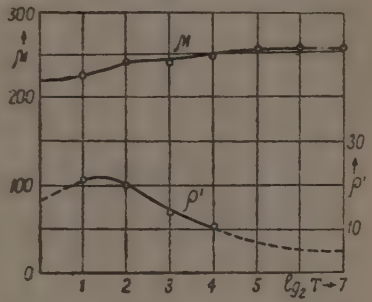

Fig. 2. Viscosity band of magnetic spectrum in soft iron.

Perpendicular to the shifts of the reflection, and either in phase with the current or with a lag of 90°, there moves a photographic plate-holder so that either the curve $B = f(H)$ or the antihysteresis curve $B = f(\sqrt{H_0^2 - H^2})$ is recorded on the plate. The movement of the plate-holder is effected by means of the following contrivance: a disk with two openings at right angles to each other is fixed to a cylinder of the rheostat generator. In these openings the end of a connecting rod can be fixed by means of a screw. The connecting rod is attached to an arm, at the end of which is a carrier with the plate-holder. The disk is fixed on the cylinder in such a position as to make the carrier, pushed by the connecting rod, move either in phase with the current generated by the rheostat generator, or with a lag of 90°.

4. After numerous tests with different specimens one of them (specimen 2) was chosen for the investigation of the magnetic spectrum. It displayed, in response to turning on and off the magnetizing current, appreciable spontaneous alterations of magnetization, which could not possibly be ascribed to skin-effect. The specimen was a wire of soft iron 89.6 cm long and 0.414 cm across, which had undergone protracted annealing in an electric furnace, and afterwards had been slowly cooled down. In a field of 0.9 oersted the permeability B/H was found to be equal to 358.

Viscosity Parameters of Specimen No. 2

m	m_1	ρ'_1	T_w sec.
216	35	4.5	2.47

The time necessary for the stationary magnetic state to be established varied about 3.0 to 3.5 sec., whereas, if computed according to Wwedensky, it should in the case of skin-effect and for the given specimen be of the order of 10^{-2} seconds.

In Fig. 2 the circles denote the values of μ and ρ' as function of $\lg T$, found from the recorded curves for the antihysteresis cycles and then computed by means of the respective quadratures. The curves in Fig. 2 represent the run of the theoretical functions of viscosity as computed from (4) and (5) by selecting the values of the parameters m, m_1, ρ'_1 and T_w (see the table). It may be concluded that the formulae for the variation of μ and ρ' with the period T, as derived from the theory of mag-

netic viscosity spectra, as well as the order of magnitude of the step variation of μ and the maximum of ρ', as forecast by this theory, have found, as has also the magnitude of transient viscosity T_u, satisfactory confirmation in the experiments described here.

The author is glad to express his deep gratitude to Prof. W. K. Arkadiev for having suggested the theme of this investigation and guided the work.

Maxwell Laboratory of Electric Magnetism
Physical Institute of the Moscow State University.

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10. XI. 1942.

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GEOPHYSICS

POLARIZATION OF THE LINES IN THE NIGHT SKY LUMINESCENCE SPECTRUM AND IN THE SPECTRUM OF NORTHERN LIGHTS

By V. L. GINSBURG

(Communicated by S. I. Wawilow, Member of the Academy, 22. XII. 1942)

As a result of investigations by Dufay*, confirmed by a number of authors ([1], [2]) luminescence of the night sky in undecomposed light has been found to be partly polarized. Khvostikov ([3]) has, moreover, arrived at a conclusion that it is the fundamental emission lines that are polarized in the spectrum of luminescence of the night sky, viz. the green and the red lines of atomic oxygen

$$\lambda = 5577\text{Å}\ (^1S_0 \rightarrow {}^1D_0) \text{ and } \lambda = 6300\text{Å}\ (^1D_0 \rightarrow {}^3P_2)$$

and the *D*-line of Na ($\lambda = 5890$Å).

When observed at a latitude $\simeq 45°$ and in a sky region near the poles of the universe, the polarization of these lines equals an average of $p_{5577} = 13.5\%$, $p_{6300} = 15.3\%$ and $p_{5890} = 9.3\%$, respectively, the error amounting to $\sim 20\%$ of the above magnitudes. In the course of the night the plane of polarization of all the lines follows the motion of the sun below the horizon; the direction of the maximum electric vector is always nearly perpendicular to the plane passing across the sun, the pole of the universe and the spectator.

The above regularities seem fully to confirm the interpretation of the night sky luminescence as being largely due to the fluorescence and scattering of sun rays. One can try and explain the penetration of the sun rays into the atmosphere during night by the fact that refraction becomes higher in the neighbourhood of the absorption lines ([4]). One may, however, imagine another mechanism of penetration of light, viz., the light of the sun may be subjected to multiple scattering in the atmosphere; if considered from this point of view, the excess of ultraviolet rays in the luminescence of the night sky appears as natural, as in the case anomalous refraction was assumed.

The hypothesis as to the luminescence of the night sky owing its origin to fluorescence may, however, be checked in the following way. The polarization of the resonance fluorescence, observed in the case of the lines $\lambda = 6300$ Å and $\lambda = 5890$ Å, and that of the green line which, if viewed from this angle, must also be due to resonance scattering upon an atom of O in a metastable condition $^1D_0$, can be computed theoretically. A comparison of the values thus obtained to those observed must contribute to the solution of this problem.

In the case of the resonance line of Na there is no need of any calculation, for polarization has safely been determined experimentally ([5]). If illuminated with

* References to a few investigations in this line, carried out previous to 1937, are to be found in a review by Khvostikov ([1]).

polarized light and viewed in a direction parallel to that of the ray (Fig. 1), polarization for the two lines taken together makes up $p_0 = \frac{Y_{||} - Y_\perp}{Y_{||} + Y_\perp} = 16.5\%$, provided lines D_1 and D_2 are equally intense in the source. In this case line D_1 is not fully polarized, while for D_2 p_0 equals 20.5%. If the rays which are responsible for the fluorescence are unpolarized and propagate in a direction parallel to that of the surface of the earth, then, viewed at an angle φ to the horizon (Fig. 2), polarization should be equal to

$$p = \frac{(Y_{||} - Y_\perp)\sin^2\varphi}{Y_{||}(1+\cos^2\varphi) + (2+\sin^2\varphi)Y_\perp} = \frac{(1-d)\sin^2\varphi}{(1+\cos^2\varphi) + (2+\sin^2\varphi)d} \qquad (1)$$

where $d = \frac{Y_\perp}{Y_{||}}$ is the coefficient of depolarization in the case of illumination with polarized light, and when viewed in a direction perpendicular to the ray (Fig. 1).

In Khvostikov's experiments $\varphi \cong 45°$, and since $p_0 = \frac{1-d}{1+d} = 16.5\%$, therefore $p \cong 4\%$. At the zenith ($\varphi = 90°$) $p \cong 8.9\%$. If the incident light is partly polarized, which would indeed take place if it were due to multiple scattering, then p would exceed the respective value in formula (1) (if vector $|\bar{E}_x| > |E_z|$, see Fig. 2). If the illuminating rays are not parallel to the horizon, this will also affect the polarization. The value obtained by Khvostikov, $p \cong 9\%$, though nearly twice as large as that deduced from formula (1), does not interfere with the fluorescence hypothesis in principle. We dwell here in detail on the considerations issuing from the use of the elementary formula (1), in order to stress the interest that would present measurements of p as a function of φ. As may be inferred from the above-said, the value of the relation $p(\varphi)$ is of great importance for the analysis of this problem. The same should be said of the fluorescence polarization measurement of Na and O in the twilight. According to the depression of the sun and the zenith distance of the sky region investigated, the measurements may serve to determine the refraction in the neighbourhood of the absorption line, etc.

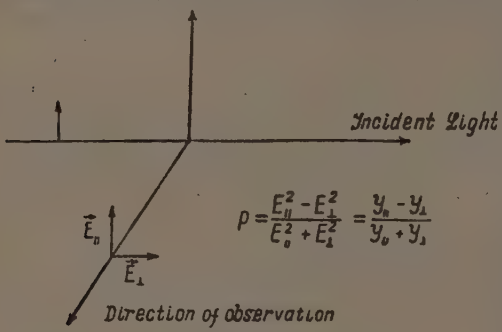

Fig. 1.

The green line which is observed in the spectrum of the night sky and in that of Aurora is emitted under a quadrupole transition $^1S_0 \rightarrow {}^1D_0$. In so far as the upper level here is the level ^1S, the green line must not be fully polarized*. This result follows from the condition that the total emission of all the Zeeman components of a given line be unpolarized when the external field $H \rightarrow 0$. The statement advanced can easily be checked by direct calculation, with the aid of matrix elements for corresponding transitions ([7]). The conclusion to the effect that the green line is unpolarized does not depend on the mechanism of excitation (by light, electron impact, etc.). Even if the polarization of the green line can take place, it will never occur outside the external field and unless special conditions are created. Thus, if an atom in the state $^1D_0$ is placed in a magnetic field, resonance fluorescence will be polarized in case the incident radiation contains nothing but wavelengths approaching those of one of the Zeeman components of the line $^1S_0 \leftarrow {}^1D_0$,

* To arrive at this conclusion use was made of the fact which seems to be safely established, viz., that the momentum of an O^{16} nucleus is equal to zero ([6]), the spectrum of oxygen thus containing no ultra-fine structure.

and relatively remote from the rest of the components of this line. It should be rather premature to assume the existence of such a mechanism now, even if we were to take into account the presence of the earth's magnetic field. Further experimental work is necessary, of course, that would support the presence of polarization of the green line, and throw light upon its dependence on various parameters. Owing to this, tho polarization of the red line of oxygen is less interesting. This line is partly polarized: its illumination is with polarized light, if viewed perpendicular to the ray (Fig. 1), and if there is no magnetic field $p_0 = \frac{2}{79} \cong 2.5\%$ [for the calculation matrix elements for the Zeeman components of quadrupole lines have been used (7)].

As the life-time of an atom τ in metastable states of the type $^1S_0$ exceeds 10^{-4} sec., degeneracy is fully removed by the earth's magnetic field ($H \cong 0.5$ gauss) for $\tau \gg T = \frac{2\pi mc}{eH} \sim 10^{-6}$ sec. Therefore, if observed along the earth's magnetic field, the radiation is fully depolarized. As a matter of fact, in order to obtain p,

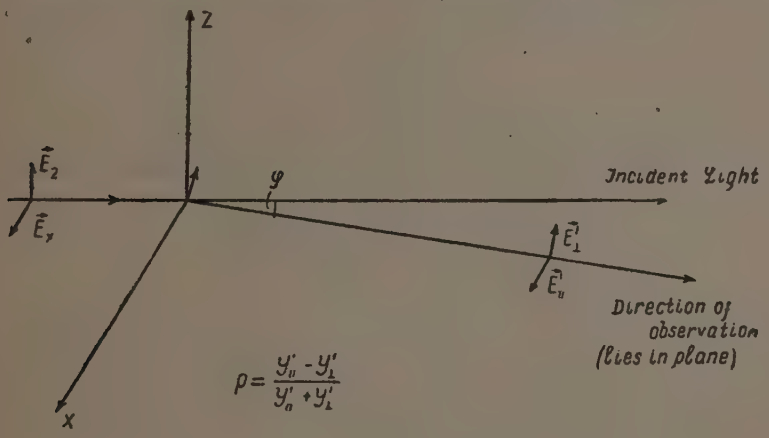

Fig. 2.

mutual orientation of the magnetic field, of the electric vector and the direction of observation should be taken into account. The effect of the field, however, may only be to reduce polarization in this case.

Measurements of luminescence polarization are, as a rule, highly valuable for determining the mechanism of excitation and some of its characteristics. This is true both for the luminescence induced by radiation, and for that due to collisions between atoms and electrons and other particles. From this point of view interest belongs not only to the polarization variations in the luminescence of the night sky, but to the possibility of polarization lines in the spectrum of Aurora. We failed to find in literature any evidence that such measurements had ever been attempted. In the case of Aurora, it may, however, be considered as safely established that we have to deal here with an impact mechanism of primary excitation*. Moreover, in so far as a definite direction has been chosen (that of primary electrons), the luminescence should, generally speaking, be supposed to be polarized. A more detailed discussion of the subject seems to be rather premature, and we shall therefore make but the following two suggestions: 1) the degree of polarization must depend on the mutual orientation of the direction of observation, of the direction in which the exciting particles were shot and that of the magnetic field; when viewed along the field, polarization may be reduced considerably;

* Unlike this, the luminescence of the night sky may presumably be put down to a photochemical process (1). In this case the polarization of luminescence must be equal to zero.

when viewed along the incident beam, $p = 0$. The polarization to be expected is that of the lines due to impacts of primary electrons; polarization of the lines due to impacts of secondary electrons is less probable.

The excitation due to impacts of the second kind and to other collisions will practically be unpolarized, although the possibility of it being polarized cannot be fully rejected either, unless the primary excitation is no isotropic one([8]). The relation between polarization and the velocity of exciting particles has been discussed by the present author ([8]). It is the molecules of nitrogen that seem mostly to be excited by electronic impacts in the spectrum of Aurora. No computation of luminescence polarization for the case of impact excitation of molecules is so far available in literature; the present author has made no such computations either. In so far, however, as it seems scarcely possible to obtain theoretically significant data as to the polarization of lines and bands to be expected for the spectrum of Aurora, it would seem expedient to undertake the corresponding experiments*.

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* Attempts to detect polarization in undispersed light can be made with particular case: the degree of polarization in this case may, however, prove to be considerably below that for separate lines.

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TECHNICAL PHYSICS

A PORTABLE SPECTROSCOPIC APPARATUS FOR ANALYSIS OF CORES FROM OIL WELLS

By S. A. BOROVICK

(Communicated by V. G. Chlopin, Member of the Academy, 9. XII. 1942)

The spectral analyses of cores from oil wells have disclosed a very high concentration of strontium in certain samples. A detailed investigation of a group of oil wells, which has been carried out under the guidance of Prof. A. P. Vinogradov by the author and T. F. Borovick-Romanova, has brought to light the existence in the carbohalogen mass of Permian deposits, of a layer with a considerable strontium content. This layer could be used as a basic stratigraphic level.

The determination of the concentration of strontium in various parts of the cores gives important correlative indications in prospecting for oil. On this consideration we in this laboratory have been employed for some time on designing a portable spectroscopic apparatus, which would allow of carrying out spectrographic analyses at the site of drilling. At present this problem is solved, and a description of the apparatus and of how to work with it is given below. Its size and weight have been made as small as possible by using a scheme of an alternating current arc with an activator. This scheme is shown in the figure, where *a b* is switch of a. c. network; TR_1, low-frequency transformer; F_1, spark gap; C_1, condenser 0.006 μF; C_2, condenser 0.5 μF; D, arc; R_1R_2, resistances; TR_2, high-frequency transformer.

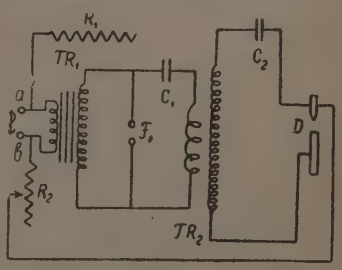

Fig. 1.

In order to introduce into the flame of the arc the material under investigation, a brass tube was taken as the lower electrode of the arc. The powdered product is put into the tube; a cork placed at the middle of the tube lifts with the help of a small rod the sample 0.5 mm above the edge of the brass tube; the distance from the upper electrode is 3 mm. The upper electrode is also made of brass.

The use of brass electrodes gives in the spectrum a large number of copper and zinc lines, which can be used for comparing the brightness of the element under consideration; for strontium a very convenient group of standard lines is obtained, the zinc lines $\lambda = 4810; 4722; 4680$ Å and the copper line 4651, which are situated near the strontium line $\lambda = 4607$ Å and whose brightness decreases gradually. With a strontium concentration 0.01% in dolomite, the brightness of the line is comparable with the weakest of these four lines. Since the brightnesss of the strontium line depends on the gross composition of the sample, one must prepare standard mixtures with a composition, corresponding to that of the analysed samples, and to plot a scale for the determination of the concentration of strontium in the samp-

les with a sufficient accuracy. In order to obtain more exact results, a number of repeated observations must be carried out, which can be done very easily by raising the cork in tube with the help of a small rod and introducing into the flame of the arc fresh portions of the sample.

The external dimensions of the apparatus are $30 \times 30 \times 15$ cm, its weight 4 kg, so that its transfer or transportation does not present any difficulties.

The novelty of the present work consists in the use of an activated arc for the analysis of the mineral raw material, in the method of introducing the sample into the arc with the help of a brass tube, and the use of zinc lines for a comparison with the strontium. It is to be hoped that the application of the apparatus described above will promote the work of oil prospecting.

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CHEMISTRY

ON THE REACTION OF ETHYLENEDIAMINE WITH ZEISE'S SALTS

By ANNA GELMAN

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If platinum is actually tetravalent in ethylenic complex compounds ([1], [2]), the latter should be optically active when the substituting groups are correspondingly selected.

It seemed most simple to prepare such compounds starting from ethylenediamine, according to the equation

$$Me\left[\begin{matrix}C_2H_4 & Cl\\ & Pt\\ Cl & Cl\end{matrix}\right] + En \rightarrow \left[\begin{matrix}C_2H_4\\ \\ Cl\end{matrix}\right.\begin{matrix}\\ PtEn\\ \\ \end{matrix}\left.\begin{matrix}\\ \\ \\ \end{matrix}\right]Cl$$

as cyclization by means of ethylenediamine would inevitably lead to the formation of two enantiomorphous forms:

$$\begin{matrix}C_2H_4\\ Cl\end{matrix}\left|\begin{matrix}\text{———}\\ \text{———}\end{matrix}\right|\begin{matrix}En\\ Cl\end{matrix} \quad \text{and} \quad \begin{matrix}En\\ \\ \end{matrix}\left|\begin{matrix}\text{———}\\ \text{———}\end{matrix}\right|\begin{matrix}C_2H_4\\ Cl,\ Cl\end{matrix}$$

It is necessary to accentuate once more that these compounds will be mirror antipodes only under the condition that in ethylene complexes the plane configuration of «bivalent platinum» is strongly distorted, owing to the formation of a double covalent bond between the ethylene molecule and platinum.

The preparation of platinum ethylene-ethylenediamine-chloride would be the first synthesis of a complex compound containing ethylene in the cation.

However, the peculiar behaviour of ethylene in the inner sphere was immediately demonstrated in this case as well. Ethylenediamine, one of the best cycle-forming compounds, proved incapable of closing the cycle with ethylene presenting the inner sphere.

Similar results were obtained with the butadiene salt as well. Both in the ethylene and in the butadiene salts ethylenediamine bridged over two atoms of platinum. A similar effect was observed by I. I. Černjaiev ([3]) in the presence of the nitro-group.

Naturally, under such conditions I was unable to prepare the ethylene compound in two enantiomorphous forms. Nevertheless, the facts observed are of independent interest. Attention is attracted by the wonderful logic with which the peculiarity of the chemical bond between ethylene and platinum is manifested.

The increased trans-influence of ethylene compared with all the other known substituting groups of the inner sphere of platinum leads to a deviation from Peyronet's rule, from Kurnakov's rule and from Chugaevs' rule of cycles for diene hydrocarbons.

It is demonstrated in the present paper that even such an excellent cycle-forming substance as ethylenediamine does not obey the rule of cycles, if one of the substituting groups is ethylene or butadiene.

In the latter case attention is attracted by the wonderful fact that the places for the bonds of ethylenediamine in platinum ethylene dichlorides are just in transposition with respect to ethylene, i. e. in places most vulnerable, places where the bond of the central atom with the substituting groups is most labile.

At the same time the coordinate Cl—Cl remains quite unaffected, although each of the chlorines could have been successfully substituted with ethylenediamine. In other words, as one of the amino-groups in ethylenediamine is maintained even in the transposition to ethylene, the second amino-group has all the reasons for substituting any of the chlorines with the formation of a cycle.

The following idea suggests itself: even if ethylene does not influence directly the capacity of ethylenediamine to form a cycle, perhaps its influence is an indirect one?

I mean that in Zeise's salt the chlorine atoms that are in transposition to ethylenediamine it is just they that should be substituted in the first place. Practically this reaction proceeds instantly and leads to the separation of an insoluble precipitate.

The coordinate Cl—Cl has even no time to come into condition capable of reaction, when the reaction on the coordinate C_2H_4—Cl is already complete.

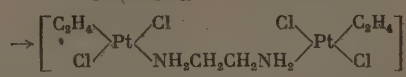
It is quite likely that the main thing is not the fact that ethylenediamine does not obey Chugaev's rule when ethylene is present in the inner sphere, but that in this case the requirements set forth by Berthollet's rule come to the foreground.

If the loss of the cycle-forming capacity by ethylenediamine is connected only with this circumstance, and not with some deeper ground, the possibility of obtaining platinum-ethylene-ethylenediamine chloride with a closed cycle by means of some roundabout course is not excluded.

Experimental. To an aqueous solution of the potassium Zeise's salt ethylenediamine was added dropwise, and instantly a clotty precipitate coloured pale-yellow began to separate. The precipitate was transferred into a Büchner funnel, filtered with suction, washed several times first with water, then with alcohol and dried in a dessicator over sulphuric acid.

The precipitate, dried to constant weight, was analysed. The analytical data obtained make it possible to assume that the reaction has proceeded according to the equation:

$$2K\,[PtC_2H_4Cl_3] + NH_2CH_2CH_2NH_2 \rightarrow$$



$[(PtC_2H_4Cl_3)_2\,En]$, mol. w. 648.28

% Pt		% Cl		% N	
Calcd.	Found	Calcd.	Found	Calcd.	Found
60.23	59.96 60.40	21.88	21.49 21.92	4.31	4.64 4.46 4.72

Weighed portion:

0.0974 g when ignited with H_2SO_4 yielded 0.0584 g of Pt; Pt = 59.96%.

0.1288 g when ignited with H_2SO_4 yielded 0.0778 g of Pt; Pt = 60.40%.

0.0790 g when reduced with Zn and precipitated with $AgNO_3$ yielded 0.0680 g of AgCl; Cl = 21.49%.

0.0932 g when fused with sodium carbonate and precipitated with $AgNO_3$ yielded 0.0826 g of AgCl; Cl = 21.92%.

0.1742 g when ignited according to Dumas gave (p = 739 mm, t = 16°C) 7.2 cm^3 N_2; N = 4.64%.

0.1178 g when ignited according to Dumas gave ($p = 753$ mm, $t = 21°C$) 4.7 cm³ N_2; N = 4.46%.

0.1540 g when ignited according to Dumas gave ($p = 747$ mm, $t = 16°C$) 6.4 cm³ N_2; N = 4.72%.

Platinum ethylene-ethylenediamine dichloride $(PtC_2H_4Cl_2)_2$ En is well soluble in 2*N* hydrochloric acid. The addition of ethylenediamine to this solution immediately yields the initial non-electrolyte, according to the scheme

$$[(PtC_2H_4Cl_2)_2\ En] \underset{En}{\overset{HC}{\rightleftarrows}} [EnH_2\ PtC_2H_4Cl_3]_2.$$

Such a repeated precipitation can be used for the purification of the dichloride, but the yield decreases considerably. For the preparation of platinum ethylene-ethylenediamine chloride it is best of all to use ethylenediamine hydrochloride (with a subsequent neutralization of the hydrochloric acid by means of a calculated amount of alkali).

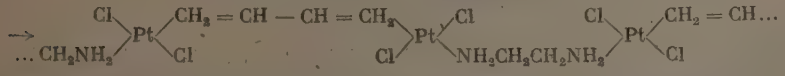
When the mother liquor from $[(PtC_2H_4Cl_2)_2En]$ is evaporated on a water bath, at first there is vigorous evolution of gas (C_2H_4), followed by the separation of a lustrous yellow precipitate which is not decomposed by water even when heated to boiling.

The substance is Pt En Cl_2. Found: Pt = 59.73%; 59.54%; calcd. for $PtEnCl_2$ Pt = 59.87%.

It is extremely curious to follow up the reaction proceeding between ethylenediamine and the butadiene salt, as butadiene, too, forms no cycle, but only a bridge between two atoms of platinum.

The reaction was carried out as in the former case and proceeded as follows:

$$K_2[(PtCl_3)_2C_4H_6] + NH_2CH_2CH_2NH_2 \rightarrow$$



Apparently, this chain can be very long. Without determining the molecular weight it is difficult to assert anything, but no appropriate solvent has been found up to now. $PtC_2H_3NH_2$—CH_2Cl_2... forms grains having an indefinite form. They do not bi-refract (an isotropic substance or crystals of cubic system). $N = 1.745$. Determined by E. E. Burova.

The analysis of the dry substance is tabulated below.

$CH_2NH_2PtCl_2CH_2 = CH...$, mol. w. 323.14

% Pt		% Cl		% N	
Calcd.	Found	Calcd.	Found	Calcd.	Found
60.42	60.18 60.59	21.54	21.59	4.33	4.54

Weighed portion:

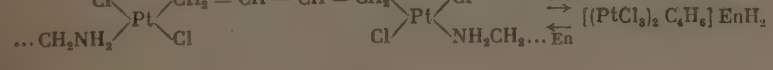
0.0864 g when ignited with H_2SO_4 yielded 0.0520 g of Pt; Pt = 60.18%.

0.0950 g when ignited with H_2SO_4 yielded 0.0578 g of Pt; Pt = 60.59%.

0.1134 g when reduced with Zn and precipitated with $AgNO_3$ yielded 0.0980 g of AgCl; Cl = 21.59%.

0.2334 g when ignited according to Dumas gave ($p = 742$ mm, $t = 16°C$) 9.4 cm³ N_2; N = 4.54%.

Platinum butadiene-ethylenediamine dichloride is as easily soluble in hydrochloric acid as the ethylene compound.

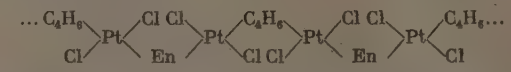


Both the ethylene and the butadiene compounds of platinum ethylenediamine dichloride are decomposed when heated to boiling with water, platinum being reduced to mètallic state.

Conclusions

1. When ethylenediamine reacts with an aqueous solution of the potassium Zeise's salt, no cycle is formed by ethylenediamine, but the latter unites two central atoms as a bridge.

2. In the case of platinum butadiene-ethylenediamine-dichloride the bridges between two central atoms are formed by butadiene, on the one hand, and by ethylenediamine, on the other.



In the solid state this molecule seems to be endlessly long.

3. The surmise has been forwarded that the reason why ethylenediamine does not follow Chugaev's rule when there is an ethylene molecule in the inner sphere, consists in the instantaneous formation of an insoluble precipitate $[(PtC_2H_4Cl_2)_2En]$ when an attempt is made to introduce ethylenediamine.

4. The incapacity of ethylenediamine to form a cycle with the central atom denies us the possibility of obtaining the supposed optically active platinum ethylene-ethylenediamine chloride.

The investigation is being continued.

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GEOLOGY

NEW GRANULOMETRIC GRADE SCALE FOR CLASTIC SEDIMENTS AND ITS APPLICATION IN GRAPHICAL CONSTRUCTION

By V. P. BATURIN

(Communicated by V. G. Chlopin, Member of the Academy, 26. XII. 1942)

Many grade scales have been suggested for the granulometric performance and classification of both recent and fossil clastic sediments. The grade scales of their own are used by the USSR, Sweden, the USA and other countries, by the representatives of different branches of such sciences as geology, soil science, oceanography, as well as by individual students. To make uniform the interpretation of granulometric types and to work out a universal classification, some or other grade scales were adopted by congresses, conferences and some large scientific research institutions. Such are the almost identical classifications adopted by the Committee for Quaternary Formations (in 1931) and by the Institute of Oceanography, and widely used in this country both for the study of fossil and recent sediments (in the present work the author uses them under the name of «reduced decimal classifications or scales»).

These scales are based on a decimal progression with the denominator 10. The terms of the progression 100, 10, 1, $^1/_{10}$, $^1/_{100}$, $^1/_{1000}$ etc. correspond to the main granulometric types of the two classifications: pebble-gravel, gravel-sand, sand-silt, silt-clay. Each group is subdivided further on the basis of other factors. Sand falls thus into fine-grained, medium and coarse-grained groups corresponding to the ratio 3 : 5 : 10, while the intervals including fine and coarse silt are related to each other as 1 : 1, etc.

This is surely a great disadvantage with the given classifications as compared to the American Udden-Wentworth scale, where the subdivisions of granulometric types correspond to the terms of the progression with the basis 2 and the denominator 2, and where, as Wentworth emphasizes it, the proportion factor of successive granulometric intervals is strictly maintained.

The lack of mathematical harmony in the classification accepted does not permit us to simplify the calculations of the statistic curves, which is a common practice with the Americans. Besides the disadvantage just mentioned, the details of granulometric composition are not displayed by the reduced decimal classification, the interval sizes of the scale being too large. More detailed subdivisions are especially needed when studying sandy-silt sediments which are often additionally dispersed on a set of sieves. There are several standards for the size grades of the sets adopted. These are the American Standards, the English Tyler Standard (IIM) and some others. In the succession of standards the ratio of one mesh size to the next is either $1 : \sqrt{2}$ or $1 : \sqrt[4]{2}$. Russian students have adopted the American standard (AFA), according to which the sets of 11 sieves have been manufactured in the USSR (OST $^{8255}/_{1200}$) with the following sizes of openings: 3.26, 1.63, 0.798, 0.561, 0.399, 0.280, 0.198, 0.141, 0.099, 0.070, 0.050. The OST $^{8255}/_{1200}$ set of sieves

does not, however, correspond to the decimal classification, since it has no chief intervals of the latter, i. e. 1, 0.5, 0.25 etc. Therefore the data of sieve analyses obtained cannot be compared to those of a usual analysis after Sabanin and Osborn.

All the above-said has prompted the author to devise a new grade scale not contradicting the decimal classification generally used in the USSR, and suffering from no disadvantages here mentioned, namely the inequality of intervals and the insufficiency of subdivision.

Having analysed various series, the author has decided upon choosing a geometric progression with the denominator $\sqrt[10]{10}$ and $n=11$*. The series is given below within the interval from 0.1 to 1 mm and is as follows: 0.10, 0.125, 0.16, 0.20. 0.25, 0.315, 0.40, 0.50, 0.63, 0.80, 1.00. It is quite clear that by means of this series the sediment may be subdivided into sufficiently small and equal size fractions (10 fractions in each decimal interval), all the subdivisions of the reduced decimal scale (0.1, 0.25, 0.5, etc.) being present among the intervals of the new one. The data of the sieve analysis carried out by means of the set of sieves made after the $\sqrt[10]{10}$ scale may be readily compared to those obtained by the usual methods according to Sabanin, Osborn and others.

The above-given geometrical progression with the denominator $\sqrt[10]{10}$ and $n=11$ was accepted in 1939 as the all-union sieve standard under the number 10203-39. The application of this standard is to be recommended for the investigation of clastic sediments, and one may hope that the sieves of this set will soon acquire general recognition among the students working in this domain.

The introduction of the scale devised by the author will considerably simplify the plotting of cumulative and especially integral (histograms) granulometric composition curves, as well as their statistical treatment. First of all, this is gained by the use of logarithms instead of true sizes. The introduction of logarithms will yield equal intervals. In other words, the grade size scale (the abscissa axis) will have equal intervals between all the fractions, which is especially convenient when constructing histograms, since, owing to the equality of all size intervals (the base of rectangles), the ordinate of the fractions (the height of separate rectangles) will correspond to their percentage**. If the intervals are unequal, which is the case with the current decimal classification, all the ordinates should be recalculated on the basis of a unit interval.

Krumbein (1) has made further simplification of the Wentworth scale, adopted in the USA. He substituted it by a new scale Φ, where the ratio of size grades in mm (ξ) and the Φ-scale units is determined after the formula

$$\varphi = -\lg_2 \xi.$$

The ratio of the Wentworth and Φ-scales is given in the table which shows that, due to this simplification, ve have to deal with integers (from —5 to 10) instead of four term fractions.

Proceeding from the Krumbein's data, the author has devised a similar scale to convert a decimal classification developed into the progression with the denominator $\sqrt[10]{10}$. The formula of the conversion into the new scale, named by the author «the γ-scale» is $\gamma = -10 \lg \xi$, where ξ is the diameter of grains in mm, and γ is the symbol of the same value in the units of the new scale.

The values of the decimal scale intervals from 0.1 to 2.0 mm are given below (see the table) in the new units of measurement.

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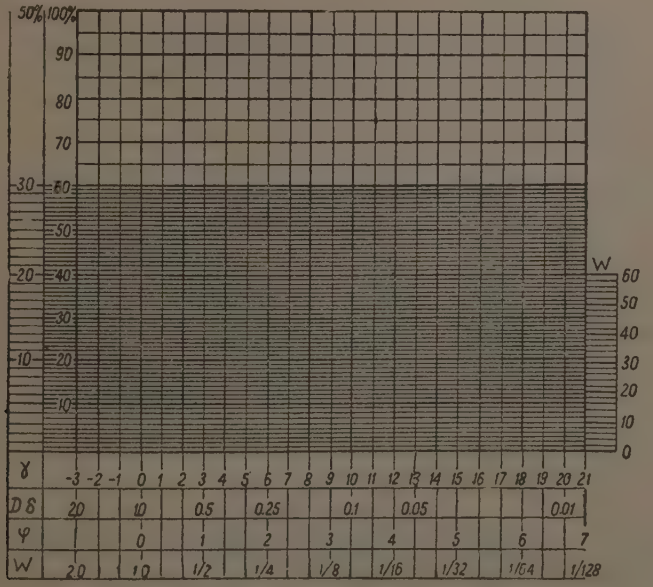
* This series was already used ih the literature on hyrology.

** When plotting an integral curve or a histogram, the sizes of the fractions are marked off along the abscissa, and the weight percentage of each fraction—along the ordinate. The ordinate is found from the condition that the area of the curve (or of the rectangle) between y and $y+\Delta y$ be equal to the content of the fraction in the interval from x to $x+\Delta x$.

Size scale after the $\sqrt[10]{10}$ decimal classification in mm	Corresponding meaning of the same size grades after the γ-scale	Size scale after the Wentworth classification in mm	Corresponding meaning of the same size grades after the Φ-scale	Size scale after the $\sqrt[10]{10}$ decimal classification in mm	Corresponding meaning of the same size grades after the γ-scale	Size scale after the Wentworth classification in mm	Corresponding meaning of the same size grades after the Φ-scale
0.008	21	1/128	7	0.16	8		
0.01	20			0.20	7		
0.012	19			0.25	6	1/4	2
0.016	18	1/64	6	0.315	5		
0.020	17			0.40	4		
0.025	16			0.50	3	1/2	1
0.031	15	1/32	5	0.63	2		
0.04	14			0.80	1		
0.05	13			1.00	0	1	0
0.063	12	1/16	4	1.25	—1		
0.08	11			1.60	—2		
0.10	10			2.00	—3	2.00	—1
0.125	9	1/8	3				

The table shows that the scale proposed by the author includes with sufficient degree of accuracy not only the current decimal classification, but also the Wentworth grade scale.



To represent graphically both the cumulative curves and histograms with the application of the γ-scale, a special plotting paper is suggested (see figure). Thanks to the above-mentioned properties of the γ-scale, the plotting paper proposed may be used for the representation in the form of cumulative curves and histograms of the analysis obtained both by means of the reduced

decimal and the Wentworth scales, which enables us to compare different types of analyses*.

The statistical treatment of the curves drawn on the plotting paper with the application of the γ-scale, namely the computation of the grading factor $\left(S_0 = \sqrt{\frac{Q_3}{Q_1}}\right)$ and the asymmetry coefficient $\left(S_k = \sqrt{\frac{Q_3 Q_1}{Md}}\right)$, is considerably simplified, since instead of numbers we have come to deal with their logarithms**.

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* The author has used different scales for the construction of cumulative curves and histograms, the scale of the latter being twice as large as that of the former. A special scale under the symbol «W» is given to construct histograms after the Wentworth scale. Fraction percentage of the reduced decimal scale is recalculated by dividing the per cent by the number of the γ-scale units included in a corresponding interval, e. g. the fraction content of the interval 3 is 10—0.5, that of the interval 4 is 0.1—0.25, etc.

** Md, a median size, is to be found by drawing a perpendicular to the abscissa axis from the point of the curve with the ordinate 50%. Q_1 and Q_3, the first and the third quartiles are to be found by drawing correspondingly the perpendicular from the points of the curve with the ordinates 25 and 75%.

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GENETICS

CHANGE IN THE CROSSOVER PROPERTIES OF A CHROMOSOME UNDER THE INFLUENCE OF MUTATION

By A. A. PROKOFYEVA-BELGOVSKAYA and M. L. BELGOVSKY

(Communicated by A. A. Borissiak, Member of the Academy, 26. VIII. 1942)

The frequency of crossing-over is known to vary according to the region of the chromosome. In the regions of attachment of the spindle fiber and in the distal sections of *Drosophila* chromosomes it is lower than in the middle parts of the chromosome limbs. These differences seem to be dependent on some regularities in the formation of chiasma rather than on the internal structure of the corresponding parts of the chromonema, since changes in the position of the regions in question, brought about by chromosome rearrangements, lead to corresponding changes in the crossing-over frequency.

On the other hand, data are also available, indicating that the liability of different sections of the chromonema to break both in the process of crossing-over and in the process of chromosome rearrangement, depends upon their internal structure as well. As the data of a number of authors show, the proximal regions of chromosomes break in the process of chromosome rearrangement with a considerably higher frequency than other chromosome regions do. Prokofyeva-Belgovskaya and Khvostova (1) and later Kaufmann (2, 3) have shown that in other chromosome regions the distribution of breaks is also not random, the latter being mostly confined to the interstitial inert sections. All these data lead to the assumption that the chromonema of inert regions is more capable of breaking than that of the active ones.

Similar data relating to chromosome breaking at crossing-over are also at hand. Grüneberg (4) has, for example, found that the frequency of crossing-over in the inert section of the *X*-chromosome to the right of *bb* in the *rst*^{3} inversion, where this section is brought far apart from the spindle fiber attachment, proves disproportionately high, as compared with the cytological length of that section.

An indication to the same phenomenon is given by the comparison of the genetic and cytological lengths of the *pn-w* and *w-ec* sections of the *Drosophila melanogaster* *X*-chromosome. These two sections are cytologically of about the same length, but according to Prokofyeva-Belgovskaya's data, the second of them includes the interstitial inert regions 3*C*4 and 3*C*8, the first being free from them. In accordance with this, the frequency of crossing-over in the *w-ec* region is much higher than in the *pn-w* one, reaching 4% in the first case and being only 0.7% in the second. This difference cannot be ascribed to the stronger suppression of crossing-over frequency in the *pn-w* region due to its greater proximity to the distal end of the chromosome, where the frequency of crossing-over is known to be generally lowered, as the discrepancies between the genetic and cytological maps of the two sections compared are approximately of the same extent, the lines connecting the *pn*, *w* and *ec* loci on the cytological and genetic maps runnig in parallel (Fig. 1).

The observation by Schultz ([5]) and by Prokofyeva-Belgovskaya, that the mutation from w^+ to w results in a cytologically visible modification of the 3*C* region, becomes especially interesting in the light of the data just described. This modification consists in the increase of the frequency of the intrachromosomal synapsis in the region in question, and in the thinning (according to Schultz' data) of the 3*C*2 band. Thus, the *w* region assumes, cytologically, the features of a heterochromatic region.

It seemed probable that the structural chromonema changes just described should in some way affect its crossover properties, although the kind of the effect to be expected could not be easily predicted from à priori reasons. On the one hand, one could suppose that the process of conjugation in the *w* region being somewhat disturbed, this would lead to a decrease in the crossover frequency, but on the other hand, if the *w* region assumes, under the influence of the *w* mutation, cytological properties rendering it similar to the heterochromatic regions, it could be expected that the frequency of breaks in the 3*C* section would be increased. In order to solve this question, corresponding genetic experiments were started.

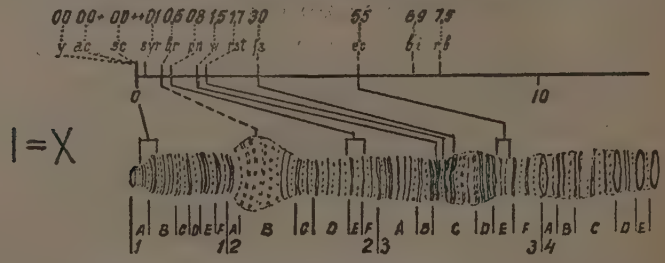

Fig. 1. Cytological and genetic maps of the left end of the *X*-chromosome (after Bridges).

A comparison was made of the frequency of crossing-over between *y* and *spl* in *y w spl*/+*w*+ and *y*+*spl*/+++ females. The *y w spl*, *w* and + stocks were taken from the stock collection of the Institute of Genetics, while the *y spl* stock derived from the corresponding crossovers which appeared among the offsprings of *y w spl*/*y cv v car* females following crossing-over in the *w*-*spl* region.

Heterozygous F_1 females were mated to the corresponding males when being not more than one day old. F_1—F_2 cultures were kept at a temperature of 26°C. The counts of F_2 flies in the two series of the experiment were performed in parallel during 6 days. The experiment yielded the following results (see the table).

P_1 *y w spl* ♀ *Xw* ♂			P_1 *y*+*spl* ♀ *X*+♂		
F_1 $\frac{y\ w\ spl}{+w+}$ ♀*X* *y w spl* ♂			F_1 $\frac{y+spl}{+++}$ ♀ *X y spl* ♂		
F_2 non-crossovers:	*y w spl*	9401	F_2 non-crossovers:	*y spl*	9175
	w	9803		+	10087
crossovers:	*y w*	130	crossovers:	*y*	96
	w spl	147		*spl*	111
	Total	19481			19469
% of crossing-over = 1.422±0.085			% of crossing-over = 1.063±0.073		

In the case when a normal w^+ allel was present between the *y* and *spl* genes, the per cent of crossing-over in the *y*-*spl* region proved significantly lower than when a recessive *w* allel was substituted for the normal one. The difference in the frequency of crossing-over is 0.359±0.112%, Diff./$m_{Diff.}$ = 3.2.

It is to be noted that the per cent of crossing-over in both series proved considerably lower than the standard one (2.9; DIS No. 9), the cause of this difference being not clear.

A cytological investigation of the *X*-chromosome of the stocks studied showed that the structure of the 3*C*1-8 region (with the *w* locus landing in the 3*C*3 band) of the *y spl* chromosome was indistinguishable from that of the standard normal stock (Fig. 2,*6—7*). This region consists of a duplication 3*C*1-4—3*C*5-8, the bands 3*C*4 and 3*C*8 possessing the properties of inert regions (1). In *y w spl* larvae the structure of the 3*C*1-8 section is markedly disturbed due to the intrachromosomal synapsis and, frequently, to the heterochromatization of the whole section (Fig. 2, *1—5*). Although heterochromatization makes the investigation of the section involved much more difficult, there are nuclei in which one can clearly see that the band 3*C*3 (including the *white* locus) is thinner than in the *y spl* chromosome or

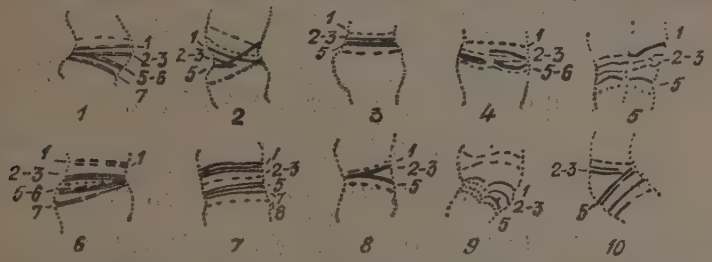

Fig. 2. Structure of the region 3*C* in *y w spl* larvae (*1—5*), *yy* + *spl* larvae (*6—7*), *y*+*spl*/*y w spl* larvae (*8—10*).

in the *X*-chromosome of the standard stock. In *y w spl*/ *y* + *spl* females the two homologous chromosomes are unlike in the 3*C*1-7 region. The whole region has a structure characteristic of a chromosome possessing a deficiency: the bands 3*C*1-8 being very close to one another in one of the homologous chromosomes and diverging in a fan-like wise in the other (Fig. 2,*8—10*).

Thus, the mutation *white* is cytologically connected with a deficiency of a part of the 3*C*3 band and with the heterochromatization of the whole section.

The result obtained shows that a mutation from w^+ to *w* influences the crossover properties of the chromosome in the *w* region. A definite statement as to the mechanism of this influence seems as yet not possible, but it can be stated that the closeness of chromosome conjugation is not a decisive factor here, as the cytological observations show that in the presence of the recessive *w* allel the conjugation is apparently not so close as in the presence of its wild type allel. Consequently, the difference in the crossing-over frequency observed should have depended upon a different liability to breaks. The increased liability to breaks of the chromosome section carrying the *w* gene reveals its similarity in this respect to the inert regions (if Grüneberg's data concerning this point are characteristic of all inert regions in general). In this connexion there suggests itself a comparison between the recessive *w* allel and the inert regions in yet another respect, viz. with regard to the action on the development of the organism. A recessive *w* allel is, apparently, completely amorphic, and the genes of the inert regions may be considered to be the more so, as deficiencies for inert sections do not affect the viability of the organism. If this analogy is not but a superfluous one, it will lead to the conclusion that a mutation from w^+ to *w* modifies the corresponding locus of the chromosome in such a way that it assumes properties, similar to those of inert regions both cytologically and genetically, this modification affecting both the morphogenetic and the crossover properties of the chromonema section involved.

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EXPERIMENTAL BIOLOGY

ON THE EFFECT PRODUCED BY PHYTONCIDES UPON THE ORGANISM

By I. TOROPZEV

(Communicated by L. A. Orbeli, Member of the Academy, 13. XII. 1942)

Of quite exceptional interest is the powerful bactericidal factor detected by B. Tokin in some plants. Thus, a paste freshly prepared from onions or garlic and placed at a distance of some centimeters from a culture of yeasts or pathogenic bacteria was found to kill them within 1—10 minutes ([1-2]). This phenomenon has at first been attributed to the effect of essential oils; in the subsequent, however, the authors arrived at the conclusion that in this case they had to deal with some rather unstable and readily disintegrating substances, for which they have coined the name of «phytoncides». These substances are emitted by the plant not only at the moment the integrity of its vegetable cells is disturbed, but also by an unaffected plant, as one of the defensive adaptations worked out by the plant in the course of its phylogeny (B. Tokin).

The discovery of phytoncides in those plants that had of old been used by men for seasoning their food calls attention to the influence of these bactericides upon the organism of mammals, and this the more so as their sterilizing effect may be rather promising from the standpoint of practical medicine.

By the moment we started our work we had at our disposal no phytoncides isolated from plants. For this reason we organized a series of experiments with the purpose to find out the effect of phytoncides as applied in the form of vapour.

Healthy rabbits, 6—10 months old, were made to inhale vapour from a paste freshly prepared from onions. The treatment lasted 4 minutes and was renewed 10 times daily, the portion of the onion paste used being every time a fresh one. The rabbits were experimented upon during 10 days, after which they were sacrificed at various terms.

Such an intense inhalation which may scarcely be required in medical practice enabled us to observe a series of clear-cut phenomena.

Run I. The rabbits were killed the day next to the last inhalation. The animals proved well fed. Their respiratory organs displayed no macroscopic alterations. The liver was of normal consistency and showed a scarcely detectable grayish hue; the heart normal. The lungs, kidneys, and in particular the liver exhale a rather strong odour of onion.

Microscopical Examination. Epithelium intact all along the larynx, trachea and bronchia. Epithelial nuclei of usual shape, showing their specific tinctorial properties. Only in some isolated cells it is possible to distinguish some swollen nuclei that stain less intensely than the rest. The submucous tissue oedematic; the lymphatic vessels distended, capillaries and arterioles hyperaemic.

Occasionally there are accumulations of round cells infiltrating the epithelial layer.

In such regions the epithelial layer is penetrated not only with lymphoid cells that are observed mostly in the basal layer, but also by polynuclear cells: the latter make their way inbetween the cells of epithelium and seem to pass into the lumen of the wind pipe. Similar pictures of migration of leucocytes are to be seen not only within restricted regions, but almost throughout the stratified ciliated epithelium.

Of not unfrequent occurrence among leucocytes are mobile elements of the type of histocytes, which also seem to rush into the epithelial layer. Near the lymphatics, in the submucous layer, one may observe an energetic proliferation of cells of the connective tissue, with a large number of histocytes directed towards the epithelium. The cartilage and the surrounding connective tissue show no visible alterations. Some of the epithelial cells of the bronchioles, showing a strongly clarified protoplasm, form bulbiform swellings directed towards the lumens of the bronchioles. The nuclei of these cells are often situated in the centre of these swellings, showing as it were an inverse polar arrangement. The sequence of this process which begins with protoplasmic alterations can easily be traced. The protoplasm increases in volume appreciably to give later on a delicate ringular outgrowth which forms a bulbiform swelling. Ultimately the nucleus moves towards the centre of the swelling. A part of these cells seem to slip out of the epithelial layer and appear in the lumen of the bronchioles. No typical desquamation of the epithelium has, however, been observed. There is but a feeble infiltration of the epithelium of fine bronchia with mobile elements; the surronding tissue, however, is rather saturated with various cells, part of which penetrate as far as to the muscular layer.

The walls of the respiratory ducts contain a considerable number of leucocytes. The alveolar epithelium is at places exfoliated; part of the cells contain vacuolized protoplasm. In the lumen of the alveoles there are observed various phagocytes with fragments of nuclei and foreign particles in the protoplasm. The vascular system of the small circle shows no peculiarities.

The liver displays no material alterations, apart from swelling of the protoplasm of the Kupfer cells which contain fine brown grains.

Kidneys: the capillaries of the convoluted tubules are injected. Their endothelium is swollen, which makes it difficult to distinguish the texture of the vascular net. In some of the cells of the epithelium of the tubules the protoplasm is markedly swollen and seems to be stuffed with weakly oxyphilic granular matter. Part of these cells are subject to desquamation.

Heart: separate fibers of the cardiac muscle show a granulosity reminding that of proteins, which makes the fine texture of the muscle hardly detectable.

The above data of morphological analysis point to the presence of an inflammatory reaction of the respiratory organs, which is accompanied with a series of peculiar phenomena.

Quite conspicuous is the stimulation of the connective tissue; the mobile elements of the latter seem to be attracted by the zone where the phytoncides are directly operative. This specific reaction is the more conspicuous, the nearer to the initial points of their activity (larynx, trachea and large bronchia). It is of interest that, in spite of the energetic proliferation of the cells of the connective tissue, which is stimulated by some agent, the epithelium of the respiratory organs remains inert. Only that of the fine bronchia responds to stimulation; the reaction, however, consist in no trivial desquamation or distrophic phenomena, but in the mobility of separate cells that slip out of the epithelial layer towards the zone of the direct activity of the substance inhaled. In connexion with the reaction on the part of the epithelium described above, the fact that the walls of the fine bronchia are but scantily infiltrated with mobile elements should be accounted for by the specific character of the epithelium of this section of the respiratory tube rather than by the concentration of the phytoncides, which becomes lower reaching deeper sections of the respiratory organs. In the lumen of the alveoles there is evidently

no depression of phagocytosis. As to the distrophic alterations observed in the liver, cardiac muscle, epithelium of the kidney and swelling of the endothelial capillaries of the kidney tubules, these are of no grave character, though pointing clearly to the presence of a general effect of the substance we are investigating. The fact that the parenchymatous organs of the experimental animals when autopsied exhale an odour of onion should certainly not be overestimated; it may, however, mean that the mechanism, by way of which the phytoncides produce their effect when inhaled, is of humoral nature. The distrophic alterations in the parenchymatous organs, not to speak of the irritation of the capillaries of the kidney tubules, should be put down to the direct effect of the phytoncides upon these organs.

Run II. The rabbits have been sacrificed the day next to the last inhalation. The autopsy revealed no essential macroscopical alterations. The parenchymatous organs exhale an odour of onion.

Microscopical Examination. The epithelial layer is intact throughout the respiratory organs; in many cells, however, the protoplasm is clarified and contains large drops of mucus. The epithelium is but poorly infiltrated with mobile elements. Corresponding pictures may be observed only among a numerous series of sections within a few fields of vision, and this only on preparations made from the larynx or bronchia of the second order. The submucous tissue is oedematic, its lymphatic vessels distended. Small arteries and capillaries hyperaemic.

There is proliferation of cells of the connective tissue and a pronounced orientation of the histocytes with respect to the epithelium. No penetration of histocytes into the basal layer of epithelium could be observed. The cartilage shows no peculiarities. Drops of mucus appear in the cells of the epithelium of fine bronchia.

«Outslipping» of separate epithelial cells into the lumen of bronchia is observed less frequently than in the foregoing experimental run. No cases of desquamation of epithelium have been observed. The proliferation of elements of the connective tissue around the bronchia is well pronounced; there is, however, no migration of mobile cells into the epithelial layer. No alterations of pulmonary alveolae.

Neither liver nor cardiac muscle show any material alterations. The epithelium of the tubules of the kidneys displays a typical picture of the so-called «turbid swelling», accompanied with exfoliation and disintegration of some of the cells.

The morphological alterations observed in these experiments point in the first line to the fact that the migration of mobile elements into the thickness of the epithelial layer, i. e. towards the zone directly affected by phytoncides, stops as soon as the phytoncides cease to penetrate into the respiratory organs. The inflammatory reaction still remains well expressed.

Run III. The rabbits have been killed 5 days upon the last inhalation. The autopsy showed no essential alterations. The liver exhaled an odour of onion.

Microscopical Examination. Epithelium of the respiratory organs without any visible changes. Submucous tissue has its normal appearance. Its lymphatics and blood vessels without changes. The connective tissue of the respiratory organs is «quiet». Only along the intrapulmonary bronchia there is a pronounced hyperplasia of the lymphoid tissue; the bronchial walls are at places infiltrated. The pulmonary tissue shows no essential alterations.

In the central sections of the lobes of the liver there are met separate cells showing a protein-like granulosity of the protoplasm, but without any alteration of the nucleus.

Cardiac muscle and kidneys normal.

The experiments of this series show that the slight catarrhal alterations of the respiratory organs come to an end rapidly; and so do the distrophic alterations of the parenchymatous organs, which persist in the liver alone. This is probably associated with the barrier-function of the organ, which seems the more probable, as an odour of onion during autopsy is emitted by the liver alone.

Run IV. The rabbits have been killed 15 days after the last inhalation. The autopsy revealed no macroscopic alterations. The liver exhaled an odour of onion.

Microscopical Examination. No material changes on the part of the mucus of the respiratory organs. The submucous tissue has its usual appearance. No inflammatory infiltrations. Near some bronchia there are hyperplastic lymphatic nods with clear-cut centres of proliferation, but without infiltration of the bronchial walls by lymphoid cells. The pulmonary tissue is normal. A careful microscopical examination of the parenchymatous organs revealed no material alterations.

Without claiming the rank of a manysided and thoroughgoing study, the observations described here make it evident that the enormous doses of phytoncides introduced by way of inhalation do not produce any profound changes in the organism of the rabbit. Those which have been observed in the parenchymatous organs are not grave and entirely reversible. Which should also be noted, is a rather pronounced stimulation of the mobile elements of the connective tissue under the influence of phytoncides.

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ZOOLOGY

A NEW AGE INDEX IN *MUSTELINAE*

By V. A. POPOV

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At the actual stage of the investigation of the animals that are caught in this country on a commercial scale, those problems will be of paramount importance, which are dealing with the causes responsible for the numerical fluctuations of those animals and with the methods of a significant prognosis of their «yield». In order to solve either of these problems, it is necessary to possess knowledge of the composition of the herd as to the age. This statement is well illustrated by the investigations carried on in Tataria with the ermine.

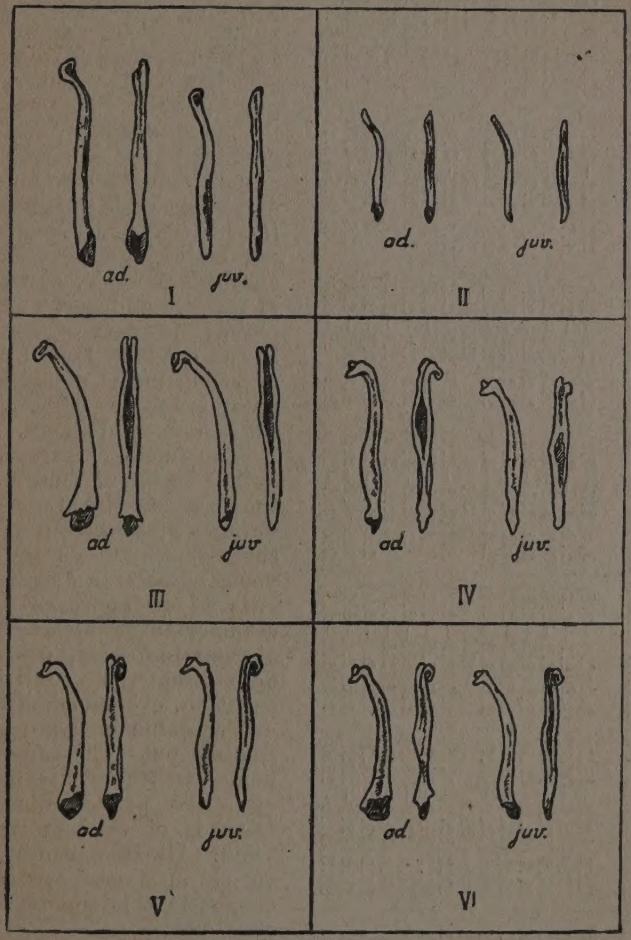
The treatment of the skull material collected during 12 years has shown that at the years, when the ermines are numerous, the number of the young in the herd rises up to 65.4%, while at those years when the animals are few in number, the per cent of the young falls as low as to 19.3% (see seasons 1937/38 and 1939/40, respectively). The same picture can be observed for the fox; in 1939, which was a hard time for the beasts, owing to deep snow, scarcity of *Murinae* and almost total lack of hares, the per cent of young in a herd fell as low as 11.8, the mean figure obtained from the examination of 972 skulls collected at various time being 41.3%. Thus, the number of young in a herd serves in most of our commercial animals as one of the fundamental criteria to judge of the numerical fluctuations within a population. It also gives an idea of whether and to what extent the year was favourable for the propagation of a given species, which contributes to a better knowledge of the ecology of the beasts, and to the prognosis of their «yield».

This is why the last years were rich in studies dealing with methods of determining the age of various animals. In all of these studies as a criterion for age determination served the degree of the wear of the teeth. This method is a good one, it is also adopted in zootechnical practice. It presents, however, considerable difficulties, and the reliability of the results obtained is largely dependent on the expertness and skill of the worker; this is because the degree of attrition is determined not from mathematical quantities, but expressed by relative notations, such as «slightly worn», «medium attrition», «strongly worn». It stands to reason that such definitions may be interpreted by various authors in a different way.

Besides, it should be taken into account that a considerable number of animals is caught in traps. So, for instance, in the Volga—Kama region up to 62% of ermines, 47% of light weasels, 57% of foxes are caught in this way. The teeth of animals caught in traps are usually strongly destroyed, which prevents the determination of their age by the method referred to above.

All these circumstances induced the author as far back as in 1938 to suggest a new method. The new method permitted of a reliable and rather simple determination of the ratio of young males after the shape and size of os penis in a herd of

Lutreola vison. Further work along this line has shown that within each species of the subfamily of marten, *Mustelinae*, these small bones fall into two sharply differentiated groups. The first group, having no thickened base at the point of fixation to the baculum of the cavernous body, is typical of young animals, while the



Os penis of *Mustelinae* (nat. size). I—*M. m. ruthena;* II—*M. erminea aestiva;* III—*L. vison;* IV—*P. p. putorius;* V—*L. l. borealis;* VI—*K. sibiricus*.

second group, characterized by a thickened well formed base of os penis, is typical of adult individuals (see figure).

We measured and weighed os penis in *Mustela erminea aestiva* Kerr, *Putorius p. putorius* L., *P. e. eversmanni* Lesson, *Kolonocus s. sibiricus* Pall.*, *Lutreola lutreola borealis* Nov. et *L. vison* Briss. (from Tataria), and *Martes martes ruthena* Ognev**. The material on martens was collected and

* Differences in the structure of os penis as dependent on age have also been pointed out by S. P. Ognev (1931).

** Moreover, we have examined a whole series of os penis belonging to foxes (*Vulpes vulpes* L.) which also showed some variation in shape of os penis for young and adult individuals.

Results of Measurements and Weighing of os penis in Different Species of *Mustelinae*

	Age-groups	Number of data	Maximum length	Maximum horizontal measurement		Maximum perpendicular measurement		Weight
				Medium part	Base	Medium part	Base	
Maries maries ruthena Ogn.	ad.	26	42.3 (40.0—45.7)	2.4 (2.0—2.9)	3.3 (2.8—3.9)	2.1 (1.9—2.4)	3.3 (2.8—3.8)	0.290 (0.200—0.350)
	juv.	30	37.0 (35.1—38.3)	1.9 (1.7—2.2)	2.1 (1.7—2.4)	1.7 (1.4—2.0)	1.7 (1.5—2.0)	0.160 (0.130—0.190)
Putorius p. putorius L.	ad.	8	36.5 (33.5—38.2)	2.4 (2.2—2.6)	3.8 (3.2—4.3)	2.7 (2.5—3.3)	5.1 (4.6—6.0)	0.337 (0.280—0.470)
	juv.	17	34.0 (31.0—37.0)	1.9 (1.5—2.6)	2.1 (1.4—3.2)	2.2 (1.5—2.8)	3.1 (2.3—3.7)	0.146 (0.080—0.240)
Putorius e. eversmanni Less.	ad.	7	39.1 (36.7—42.5)	2.6 (2.3—2.8)	4.2 (3.3—5.4)	3.1 (2.8—3.3)	5.7 (5.2—6.4)	0.436 (0.370—0.530)
	juv.	30	36.6 (33.9—40.6)	2.5 (1.8—2.9)	2,4 (1.8—3.2)	2.6 (2.3—3.2)	3.1 (2.4—4.0)	0.200 (0.130—0.280)
Kolonocus sibiricus Pall.	ad.	4	35.1	2.4	3.7	2.6	5.3	0.270
	juv.	7	33.2 (32.5—34.2)	2.1 (1.9—2.3)	1.1 (0.8—2.2)	1.9 (1.8—2.2)	2.4 (2.1—3.0)	0.107 (0.060—0.150)
Lutreola l. borealis Nov.	ad.	6	35.9 (34.8—37.3)	2.7 (2.5—2.8)	3.8 (3.5—4.0)	2.6 (2.5—2.8)	4.9 (4.5—5.3)	0.292 (0.230—0.380)
	juv.	10	33.5 (32.6—34.8)	2.3 (2.0—2.4)	1.3 (1.0—1.6)	2.1 (1.9—2.2)	2.0 (1.5—2.3)	0.118 (0.100—0.130)
Lutreola vison Briss.	ad.	30	44.6 (39.9—49.7)	3.1 (2.5—3.5)	4.4 (2.9—5.4)	2.5 (2.1—2.9)	5.8 (4.4—6.8)	0.336 (0.240—0.450)
	juv.	30	41.7 (37.9—45.2)	2.9 (2.6—3.4)	2.0 (1.4—2.9)	2.1 (1.8—2.4)	3.4 (2.5—4.2)	0.167 (0.130—0.210)
Mustela ermínea aestiva Kerr	ad.	30	25.1 (22.9—27.8)	1.5 (1.2—1.7)	1.6 (1.4—2.0)	1.2 (1.0—1.4)	2.3 (1.9—3.0)	0.042 (0.033—0.048)
	juv.	30	23.5 (21.0—25.0)	1.4 (1.2—1.7)	0.6 (0.4—0.8)	0.9 (0.6—1.1)	0.7 (0.5—1.2)	0.023 (0.016—0.032)

treated by D.I.Aspisov (1940). The results of all the measurements are summarized in the table.

In all the species enumerated os penis of adult individuals shows a number of characters that are not the same for young and adult individuals (the base of the bone was measured perpendicularly and horizontally and the bone weighed), which makes it possible to isolate safely and without any difficulty the group of new birth among the male population of *Mustelinae*. If we are to assume that the sex ratio in a herd of *Mustelinae* approaches unity, and the dying-off of females and males of the first age groups proceeds regularly (at least in the ermine), then by the number of young males determined after os penis it may be possible to evaluate the increment of a herd.

The method suggested by the author makes it thus possible after the shape and size of os penis collected during a given season, to obtain fully significant data on the per cent of young animals in a herd. It also permits of an approach to a number of important problems of the ecology of separate species, such as the finding out of zones with a similar rate of propagation, evaluation of favourable or unfavourable meteorological factors, finding out the causes underlying numerical fluctuation in various species, and perfectioning the actual methods of the «prognosis» of the yield. All this would considerably enrich our knowledge of the animals caught in this country on an industrial scale.

Conclusions. Up to the present time age determination and subdivision into groups (young, adult) used to be made after the degree of tooth abrasion. The results obtained by this method often lack precision. The author suggests a method of a reliable determination in all species of the subfamily *Mustelinae* of young and adult individuals after the shape and size of os penis (see figure and table).

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